

AIR WAR COLLEGE

AIR UNIVERSITY

THE FUTURE OF AMERICAN POWER:
ENERGY AND NATIONAL SECURITY

by

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Biography

Ms. Jennifer Morgan was born in Zanesville, Ohio. She entered the Air Force in 1995 after receiving her commission as a distinguished graduate of the ROTC program at the University of Southern Mississippi in Hattiesburg, Mississippi. Upon departure from Active Duty with the Air Force she worked as a distribution supervisor for Anchor Hocking Glass in Lancaster, Ohio. Ms. Morgan entered federal civil service in 2002. Ms. Morgan has been assigned to acquisition management positions at the Air Armament Center, Aeronautical Systems Center and Headquarters Air Force, as well as a financial management position at Headquarters Air Force. Prior to assuming her current position, Ms. Morgan served as the Research, Development, Test and Evaluation Appropriation Manager in the Budget Investment Directorate, Deputy Assistant Secretary for Budget, Office of the Assistant Secretary of the Air Force for Financial Management and Comptroller, Headquarters U.S. Air Force. She is currently a student at the Air War College at Maxwell Air Force Base, Alabama.

Introduction

Energy stands to be center stage in future political discussions not only in terms of economic growth within the United States, but in its relevance to National Security. Increasing living standards, growing populations, environmental politics and economic growth are all exerting pressure on the world's energy supplies. The continued reliance on imported fossil fuels presents significant economic, political, military and strategic challenges to the United States. The purchase of energy sources from outside the United States is typically not a problem. However, we are buying these energy sources from unfriendly and unstable parts of the world. The United States is also facing a challenge to its global leadership. The absence of the United States has not stopped the momentum internationally towards global environmental agreements and the US risks being left behind. Finally, the United States expends significant levels of human, political and monetary capital to ensure access to foreign sources of energy. The question to the American people and its leadership is – does this make sense when we have other options?

While most of the world relies upon fossil fuels, renewable energy sources are becoming more available. Nations such as China, previously energy independent, are now net importers of fossil fuels simply to sustain their level of economic growth. The need to import energy resources has led these countries to take a more active role in global economics and politics. While the United States generally welcomes more nations into the world economic fold, the presence of additional (not always friendly) players in global politics will complicate the goal of the United States “to seek and support democratic movements and institutions in every nation and culture, with the ultimate goal of ending tyranny in our world”.¹ Today the United States fights economic, humanitarian and political tyranny around the globe but is doing little to secure

its own energy future. In the absence of preparation for an energy crisis, the United States will be forced to fight energy tyranny to guarantee its own survival, leaving little capability to protect others against tyranny. Increased investment in alternative energy sources will bolster United States National Security through energy diversification, preservation of natural resources and avoidance of competition for energy resources across the globe.

The role of energy in the prosperity of a nation goes well beyond the ability to turn on a light bulb or drive a car across the countryside. The strength of a nation lies both in its ability to project national power beyond its borders and the ability to support its people and economy within its borders. Currently the projection of state power abroad is highly dependent upon fossil fuels for the manufacture of equipment and the power to run the equipment. The economy inside a nation is also dependent upon the reliable availability of energy, both in electricity to run our houses, stores and factories, but also in fuel for the transportation system to move people and goods to manufacturers and consumers.

A brief review of previous world powers reveals a concerning pattern regarding energy use. In the book *American Theocracy* the author Kevin Phillips outlines a cycle of energy dominance contributing to the emergence of national power, followed by a lack of infrastructure investment eventually leading to decline in world leadership and national power. Phillips writes of the Dutch dominance fueled by wind and water, and the British world leadership powered by coal, yet both their power eventually declined. Kevin Phillips argues this is due to over reliance on a single form of energy, a lack of innovation and a failure to invest in the infrastructure of the nation. “The evidence is that leading world economic powers, after an energy golden era, lose their magic – and not by accident. The infrastructures created by these unusual, even quirky, successes eventually became economic obstacle courses and inertia-bound burdens”². The

challenge for the United States will be to recognize it is vulnerable to this cycle, and to take the necessary actions not to fall victim to this energy cycle.

With Fiscal Year 2010 Department of Defense budget appropriations totaling more than \$636 billion and the Department of State Foreign Operations budget request exceeding \$34 billion, it is evident the United States values its role as the world's single economic, political and military hegemon. However, the United States' ability to remain relevant in this future world depends greatly on the resources available to generate energy and the amount of demand that must be served. The United Nations Development Program defines Energy Security as "... the availability of energy at all times in various forms, in sufficient quantities, and at affordable prices, without unacceptable or irreversible impact on the environment"³. The availability of sufficient and affordable energy through renewable sources will provide the innovative capacity that spurs economic growth and enable greater international leadership.

The March 2006 National Security Strategy of the United States of America highlights energy security as a major challenge.⁴ The National Security Strategy further identifies opening, integrating, and diversifying energy markets to ensure energy independence as a main principle of the United States going forward.⁵ "Keeping America competitive requires affordable energy. And here we have a serious problem: America is addicted to oil [and other fossil fuels], which is often imported from unstable parts of the world".⁶ The first step in fighting an addiction is to recognize you have a problem.

Energy Landscape

The sources generating energy around the globe are fairly diverse, but are still heavily reliant on fossil fuels. According to the International Energy Agency report "Key World Energy Statistics 2009", fossil fuels provided 86% of the energy supply in 1973. Despite the emergence

of alternative energy sources and technologies, greater than 80% of the world's energy supply in 2007 was generated from fossil fuels.⁷ The energy landscape within the United States is a complex web with multiple sources feeding multiple demand areas that can vary from region to region within the country. However, the United States generally depends on a few major sources of energy, all of which are fossil fuels. First is oil for the transportation industry. Then coal for the generation of electricity, with natural gas rounding out the top three supporting industry and residential uses.⁸

Energy around the globe is equally dependent upon fossil fuels, particularly in developing nations. The use of fossil fuels for energy generation today is economically feasible and advantageous, but is not sustainable over the long term. The United States is fortunate to contain an abundance of these fossil fuel sources on our soil, yet it is proving insufficient to meet its energy demands. Fossil fuels take millions of years to create and at some point will be depleted. Additionally the burning of fossil fuel pollutes the environment and is a point of major contention in the debate on climate change.

The generation of nearly 50% of US electricity demand is fueled by coal largely from domestic sources.⁹ Fortunately, the United States holds the world's largest reserves of coal. The top five countries with the largest coal reserves are also the world's largest producers of coal.¹⁰ It is also important to note both China and India, the two most populous countries in the world, are the first and third (respectively) highest producers of coal, yet are not in the top ten countries exporting coal.¹¹ The logical interpretation of this data is the massive amount of coal produced is going to support the internal demand for energy generation.

The United States is the 3rd largest oil producer in the world yet relies on international sources to supply more than 50% of its oil needs.¹² In fact the United States imports nearly three

times more than Japan, the next largest importer of oil. Most of the nations comprising the largest exporters of oil present political complications for the United States. Half of the top ten exporters are in the Middle East, a region marred with turmoil and arguably the root of Islamic Fundamentalist Terrorism.¹³ Of the remaining top five exporters, only two could be considered friendly and politically stable – Mexico and Norway.¹⁴

Another large portion of United States electricity generation is fueled by natural gas. The United States is the second largest producer of natural gas.¹⁵ However, domestic production is insufficient to meet domestic needs, as the United States is also the second largest importer of natural gas.¹⁶ The physical properties of natural gas complicate the transport of mass quantities over long ranges as compared to oil or coal. Natural gas is typically transported in mass via networks of pipelines from the production source to the countries and areas of demand or consumption. This is a tremendous advantage for Europe and Asia. Canada is the only country in the American continental landmass (North, Middle, South America combined) that ranks in the top ten exporters of natural gas.¹⁷ “The net volume of U.S. natural gas imports decreased by 20.9 percent from 2007 to 2008, as both pipeline imports from Canada and LNG [liquefied natural gas] imports declined and United States exports increased.”¹⁸ The fall in imported natural gas to the United States reflects the increased need for natural gas in other countries willing to compete for available global supplies.¹⁹

The United States ranks in the top 10 producers of each of these three major fossil fuels. However it is clear the production is falling short of domestic demand. While these resources are abundant, available and accessible today, they may not remain so in the near future. Oil, coal and natural gas are fossil fuels that require millions of years to create. As developing nations increase their energy consumption they will increasingly compete with the United States for

access to energy sources. The key to ensuring our energy security is diversity in the regions from which energy resources come and in the types of energy resource on which we rely.²⁰

Environmental Impact

It is almost impossible to discuss the future of energy in the 21st Century without a discussion on the environmental impacts of energy generation. The use of fossil fuels requires the extraction of the fuel (mining, drilling), the transportation of the fossil fuels, refining into a usable form, and finally the burning of the fuel to create energy. Each of these steps requires the consumption of energy and creates emissions from the burning of the fossil fuels. In comparison, the use of renewable energy is less energy intensive and has little to no hazardous impact on the environment once the infrastructure is in place. The discussion on Climate Change has dominated the international environmental arena for over a decade. The Intergovernmental Panel on Climate Change (IPCC), established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO), issued “Climate Change 2007: Synthesis Report”, the fourth assessment report since the first was issued in 1990. The IPCC defines climate change as “a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer”²¹.

It is a well-accepted fact the Earth’s climate changes naturally over the millennia. The ongoing debate is over anthropogenic (caused by humans) climate change. The main anthropogenic contributor to climate change is green house gases (GHGs). “Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004”²². The IPCC report attributes the largest growth in GHG emissions to the generation of the energy supply, transportation and industry. While the scientists and global

environmental community at large continue to debate the true effects of green house gases and anthropogenic contributors to climate change, there remains experiential evidence of the environmental impact to the burning of fossil fuels. All one must do is stand behind a running car and breathe deeply.

Competition for Resources

“The United States was self-sufficient in energy until the late 1950s when energy consumption began to outpace domestic production. At that point, the Nation began to import more energy to fill the gap. In 2008, net imported energy accounted for 26 percent of all energy consumed”.²³ The United States is in the top ten worldwide importers of Oil and Natural Gas, the number one and two sources of energy generation within the United States. The need to import energy sources requires the United States to maintain relationships with exporters of these energy resources – many of which present significant political challenges. Complicating the energy picture further, populations across the globe are growing and many of these populous nations are developing beyond third world standards of living, increasing the demand for energy sources. The net result is increased competition for access to these energy sources.

The two primary competitors to the United States for energy will be China and India. Both nations have populations over one billion and have seen historically significant levels of sustained economic growth – all leading to an increased demand for energy. Both governments have established plans to continue economic growth well into the future, reducing poverty across their populations, increasing the middle class and raising living standards. In an effort to meet the rising demand for energy each country is developing methods to secure access to fossil fuels. A main recommendation in India’s Integrated Energy Policy is to “raise the level of diplomacy to access hydrocarbon reserves overseas and gas pipelines to India” as well as “redouble

exploration efforts for oil, gas and coal”.²⁴ China is also increasing its presence beyond its borders and beyond Asia at large. This increased global presence has dramatic implications for United States diplomatic relationships with China, India and other countries. The Chinese are increasingly willing to establish relationships with other countries, complicating United States efforts to spread democracy, freedom and human rights throughout the world. Previously the United States was the only option. That is no longer true and a relationship with China is usually limited to economics and does not come with any messy strings. “The state-owned oil company, China National Petroleum Company (CNPC), demonstrated its increasing confidence and its greater international engagement with major investments in overseas oil projects. In 1997, the decision by the CNPC to pledge \$8 billion for oil concessions in Kazakhstan, Venezuela, Iraq and Sudan represented a significant change in strategic orientation and involved outbidding a number of major Western oil companies”.²⁵

The competition for resources is likely to be a flash point in Asia and more widely across the globe. The process by which China and India grow will determine the future prosperity and peace of the region. “The entry of Chinese and Indian oil companies competing for the same resources has provided the resource owners many more options in securing more favorable terms”.²⁶ The United States is no longer the single “go to” nation for business deals, foreign direct investment, or security assistance. The increased competition could lead to more expensive resources, or worse a single nation with a monopoly on a specific resource. It is not such a big step to go from an energy monopoly to energy tyranny.

Renewable Energy

Increasingly modern and emerging countries are transitioning to alternative and renewable sources of energy. Investment in renewable energy is one of the biggest steps the

United States can take to meet future energy demands. For the purposes of this paper, renewable energy focuses on solar, wind, and hydro. These are non-polluting types of renewable energy and are all methods of energy generation that do not deplete the source when converted to usable forms of energy such as electricity. Increased use of renewable energy will increase United States' energy diversification, decrease consumption of natural resources and decrease the need to compete in the global market for energy. Currently renewable energy sources account for only 7% of total energy supply sources within the United States.²⁷ The largest consumer of renewable energy is the generation of electricity, yet it still accounts for only 9% of the electricity generated.²⁸

With increased consumer awareness, government incentives, technological advancements and increased costs of fossil fuels, the use of renewable energy is on the rise in the United States. Solar energy can be used to generate thermal energy (ex. to heat water) or to generate electricity (via photovoltaic panels). The production and sale of photovoltaic systems has increased dramatically within the United States in the last 10 years.²⁹ This is partially due to technological advances resulting in more efficient solar systems and increased demand reducing the cost per system to the consumer. There are a number of solar farms around the United States but their spread is impeded by the need for surface area (typically large tracts of land). The major benefit of solar power is the ease of installation at the individual consumer level. More and more consumers are installing residential solar systems to reduce the energy they must purchase from public utilities that are typically powered by fossil fuels.

“Water is currently the leading renewable energy source used by electric utilities to generate electric power. Hydroelectric plants operate where suitable waterways are available; many of the best of these sites have already been developed. Generating electricity using water

has several advantages. The major advantage is that water is a source of cheap power. In addition, because there is no fuel combustion, there is little air pollution in comparison with fossil fuel plants and limited thermal pollution compared with nuclear plants. Like other energy sources, the use of water for generation has limitations, including environmental impacts caused by damming rivers and streams, which affects the habitats of the local plant, fish, and animal life”.³⁰

The use of wind to generate electricity is gaining market share within the United States. “The pace of utility-scale wind development in 2008 was more than 60% higher than the previous U.S. record of 5,249 MW, set in 2007. To date, all wind power installations in the U.S. have been onshore, though there are now 11 “advanced-stage” offshore wind project proposals totaling more than 2,000 MW in various phases of development in U.S. waters”.³¹ In fact the United States is now the world’s leader in wind power.³² Unfortunately it still makes up a very small percentage of electricity generated in the United States.³³

The increased use of renewable energy sources is necessary for the future success of the United States. The Energy Information Agency of the United States government states two main reasons why the United States does not use more renewable energy: 1) renewable energy technologies are capital-intensive and 2) renewable resources are often geographically remote.³⁴ These two reasons will require significant federal government leadership through incentives to private industry and more importantly investment in an energy infrastructure to support the promulgation of renewable energy generation. Fortunately the “Green Movement” has picked up speed in popular culture in the United States. Innumerable celebrities are vocal in their support for green technologies, which in turn increases awareness on Main Street to the point now anything “Green” carries a chic cachet. Increased support on Main Street will exert

pressure on politicians who are in a position to enact federal incentives and infrastructure investment needed to increase renewable energy generation and usage within the United States.

What does it all mean?

The United States must prepare for a future where the use of fossil fuels is no longer efficient due to high prices, limited access and political difficulties. This plan must include efforts along the entire energy supply and consumption chain. To diversify energy sources, any national energy plan must increase the installation and generation capacity of renewable energy. Once the generation capacity is installed, transmission networks are needed to move the electricity to the areas of demand. The building of a transmission network will likely fall upon the government due to the massive capital investment costs required. Without the transmission network, expanded renewable energy capacity is unlikely. Recently a 4,000MW wind farm (enough to power 1.3 million homes) planned for installation in Texas was cancelled due to a lack of transmission lines.³⁵

The future of the energy landscape within the United States is also dependent upon the continued increase in energy efficiency and conservation. Education and increased awareness of the everyday consumer is aiding in efficiency. The use of compact fluorescent light bulbs, Energy Star rated appliances, programmable thermostats and more are helping the consumer save money and reduce the energy burden around the nation. Businesses are also getting in the efficiency and conservation business as a means to improve profits by reducing operating expenses. The federal government also supports energy savings investments via tax credits and other incentives. With advances in technology the ability to transfer energy demand from fossil fuels to renewable energy sources is also likely to gain momentum. It is estimated that 1.5 million electric cars could be on US highways by 2015, rising to over 10 million by 2020.³⁶

China and India recognize the impending energy crisis and are both enacting plans to ensure energy security well into the future. It is difficult to say the same for the United States. While both China and India are working to fortify economic ties to suppliers of fossil fuels, a parallel plan to maximize the installation and use of renewable energy sources is also afoot. “China has set a goal of generating 10 percent of its electricity from renewable energy sources by 2010, and 15 percent by 2020.”³⁷ India is focused on diversifying their energy sources by increasing the use of renewable energy. The government of India’s “objective...would be to develop a solar industry in India that is capable of delivering solar energy competitively against fossil options”.³⁸

Finally, the United States must stand up and lead. As the single hegemon in this unipolar world, America stands out as a beacon of hope, inspiration and a land of opportunity. Failure to lean forward and embrace clean energy technology, participate in international agreements and the failure to develop a comprehensive energy policy may leave the US behind as the world coalesces on a common goal. Thomas Friedman recently wrote of a Chinese official who said “China was asleep during the Industrial Revolution. She was just waking during the Information Technology Revolution. She intends to participate fully in the Green Revolution.”³⁹ The United States cannot afford to be late to the revolution, much less not show up at all.

From the Declaration of Independence and the writing of the Constitution, through Manifest Destiny and the eventual building of the Interstate Highway System, the leaders of the United States have seen fit to provide a vision, establish guideposts, and build an infrastructure – be it the rule of law or physical means –allowing the individual citizens of the nation the liberty and ability to pursue their dreams. If the United States wants to remain a world leader, it must lead – lead, cooperate in, and guide international schemes to address Climate Change, invest in

renewable energy, and maintain positive relations around world. All this can be done while preserving the free market, capitalism and entrepreneurial spirit that made the United States the world leader it is today.

Conclusion

There is little doubt that United States energy consumption has risen over the past several decades. The Energy Information Administration reports United States energy consumption increased by more than 300% since 1949.⁴⁰ The ability to meet the increasing energy demands of the United States is a growing concern at the national level. Increased investment in alternative energy will bolster United States National Security through energy diversification, preservation of our natural resources and avoidance of competition for energy resources across the globe.

The generation of electricity and supplying the growing US energy demands may seem to be a matter of domestic policy. In actuality this subject has significant security implications for the United States. The eventual exhaustion of our natural resources, the economic impact of increased imports to generate energy and competition across the globe for these dwindling energy resources creates a complicated mixture of foreign entanglements. A future with insufficient domestic natural resources to power our nation would create the need to buy energy from outside sources. Already today many countries are too dependent upon foreign oil, which is often imported from unstable parts of the world.⁴¹ The import of foreign oil is a multi-billion dollar industry with profits benefiting those outside the United States. Investment and use of domestic renewable energy would benefit the economy of the United States.

Finally, the increasing energy needs of other nations results in competition across the globe. China serves as a current example of future entanglements. China's reticence to engage

outside its borders is waning. The Chinese economy continues to grow at staggering rates, resulting in increased demand for energy. China was largely energy self-sufficient 25 years ago; today approximately 40% of their oil supply is imported.⁴² Similar to the United States strategy to secure access to foreign supplies, China and India are increasing diplomatic efforts across the globe. Both countries are increasing communication and relationships in oil rich areas of the world such as South America and the Middle East. The United States will be forced to keep pace with China and India and their diplomatic efforts.

The renewable energy sector in the United States has tremendous capacity for growth. A positive policy climate at the national level supports investment in renewable energy infrastructure. The American Recovery and Reinvestment Act of 2009 extended a production tax credit and established a new program for grants from the Department of Treasury designed specifically to encourage investment in renewable energy infrastructure.⁴³ However, significant challenges remain in the ability of renewable energy sources to increase their market share of the energy supply. To increase the renewable energy market share, additional investment in generation capability is needed, consumer education is required and most importantly transmission infrastructure must be built. The policy environment at the national and local level encourages investment in generation but once generated the electricity is not able to get to the areas demanding additional electricity. The American Wind Energy Association Annual Wind Industry Report reports that close to 300,000 megawatts of proposed wind projects are currently waiting to connect to the grid.⁴⁴ Regardless of the generation source (fossil fuel vs. renewable energy) the electricity transmission grid in the United States desperately needs modernization. The United States must create a positive policy environment and financial incentives to modernize the electrical grid and create the ability to push the electricity to where it is needed.

The ability to meet future energy demands is vital to United States National Security. While a single source of energy is not the solution, the investment in and use of a diverse portfolio of energy generating technologies is the best way to meet future energy needs of the nation. The availability of domestic natural resources will eventually dissipate. The economic and political implications of foreign supplies of energy continue to grow more complex. Not only is the United States accelerating the transfer of wealth to foreign benefactors, the political price may soon become too high. While energy prices are still relatively affordable the United States should invest in creating a generation and transmission network of renewable energy sources. The United States would be positioned to meet the energy demands of the future while retaining valuable natural resources. Renewable energy will play a key role in the National Security of the United States by diversifying the sources of energy, aiding in the preservation of our natural resources and diminishing the need to compete across the globe for access to fossil fuels. “Always and especially in the crucible of these global challenges, our overriding duty is to protect and advance America's security, interests and values, to keep our people, our nation and our allies secure, to promote economic growth and shared prosperity at home and abroad, and to strengthen America's position of global leadership so we remain a positive force in the world, whether in working to preserve the health of our planet or expanding opportunity for people on the margins whose progress and prosperity will add to our own.”⁴⁵ None of this will be possible in the absence of energy security.

Illustrations

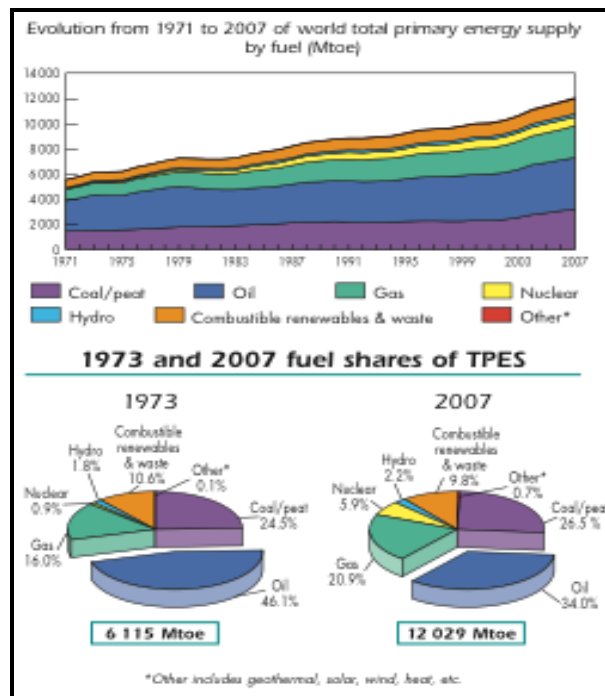


Figure 1 World Total Primary Energy Supply⁴⁶

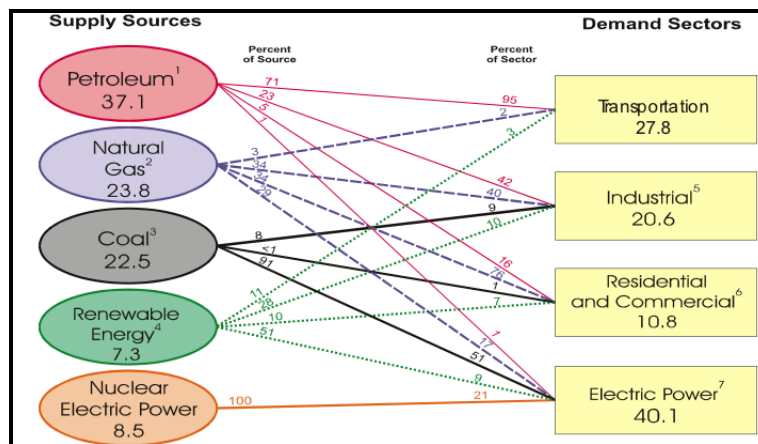


Figure 2 Primary US Energy Consumption by Source and Sector, 2008⁴⁷

Region/Country (Million Short Tons)	Recoverable Anthracite and Bituminous	Recoverable Lignite and Subbituminous	Total Recoverable Coal
United States	125,412	145,306	270,718
Russia	54,110	118,964	173,074
China	68,564	57,651	126,215
India	99,302	2,601	101,903
Australia	42,549	43,982	86,531
World Total	530,438	470,475	1,000,912

Figure 3 World Estimated Recoverable Coal⁴⁸

Producers	Hard Coal (Mt)	Net Exporters	Hard Coal (Mt)	Net Importers	Hard Coal (Mt)
People's Rep. of China	2,761	Australia	252	Japan	186
United States	1,007	Indonesia	203	Korea	100
India	489	Russian Federation	76	Chinese Taipei	66
Australia	325	Colombia	74	India	58
Russian Federation	247	South Africa	60	Germany	46
Indonesia	246	United States	43	United Kingdom	43
South Africa	236	Kazakhstan	27	Italy	25
Kazakhstan	104	Canada	20	France	21
Poland	84	Vietnam	20	Turkey	19
Colombia	79	Venezuela	6	Spain	19
Rest of the World	267	Others	12	Others	195
World	5,845	Total	793	Total	778
2008 Data					

Figure 4 Producers, Net Exporters and Net Importers of Coal⁴⁹

Producers	Mt	Net Exporters	Mt	Net Importers	Mt
Saudi Arabia	509	Saudi Arabia	339	United States	573
Russian Federation	485	Russian Federation	256	Japan	206
United States	300	Islamic Rep. of Iran	130	People's Rep. of China	159
Islamic Rep. of Iran	214	Nigeria	112	India	122
People's Rep. of China	190	United Arab Emirates	105	Korea	118
Mexico	159	Norway	97	Germany	106
Canada	155	Mexico	89	Italy	94
Kuwait	145	Angola	83	France	81
Venezuela	137	Kuwait	82	Spain	59
United Arab Emirates	136	Iraq	81	Netherlands	58
Rest of the World	1,511	Others	583	Others	515
World	3,941	Total	1,957	Total	2,091
2007 Data					

Figure 5 Producers, Net Exporters and Net Importers of Crude Oil⁵⁰

Producers	bcm	Net Exporters	bcm	Net Importers	bcm
Russian Federation	657	Russian Federation	187	Japan	95
United States	583	Norway	96	United States	84
Canada	175	Canada	88	Germany	79
Islamic Rep. of Iran	121	Qatar	58	Italy	77
Norway	103	Algeria	58	Ukraine	53
Netherlands	85	Turkmenistan	51	France	44
Algeria	82	Netherlands	36	Spain	39
Qatar	79	Indonesia	34	Turkey	36
Indonesia	77	Malaysia	22	Korea	36
People's Rep. of China	76	Nigeria	21	United Kingdom	26
Rest of the World	1,111	Others	149	Others	214
World	3,149	Total	800	Total	783
2008 Data					

Figure 6 Producers, Exporters and Importers of Natural Gas⁵¹

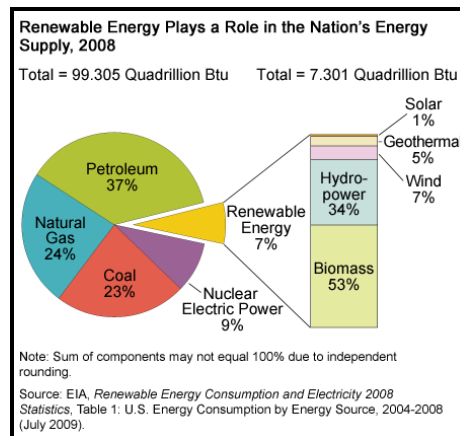


Figure 7 Renewable Energy Role in US Energy Supply, 2008⁵²

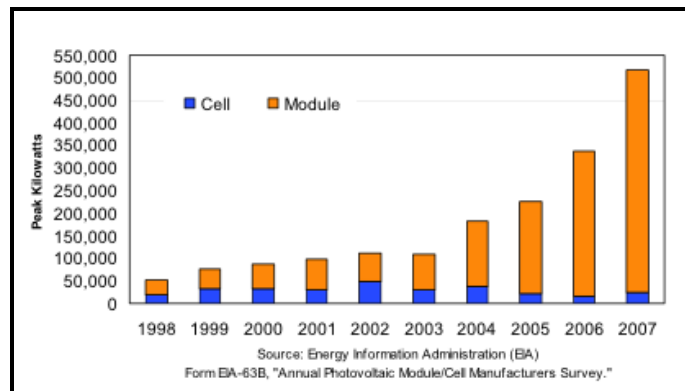


Figure 8 Photovoltaic Cell and Module Shipments, 1998 - 2007⁵³

Cumulative Capacity (end of 2008)	MW
United States	25,369
Germany	23,933
Spain	16,453
China	12,121
India	9,655
Italy	3,731
France	3,671
United Kingdom	3,263
Denmark	3,159
Portugal	2,829
Rest of the World	18,106
Total	122,290

Figure 9 International Rankings of Wind Power Capacity⁵⁴

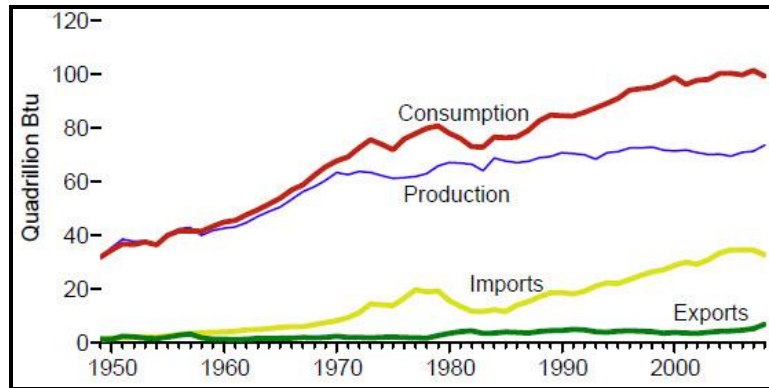


Figure 10 Primary Energy Overview for United States⁵⁵

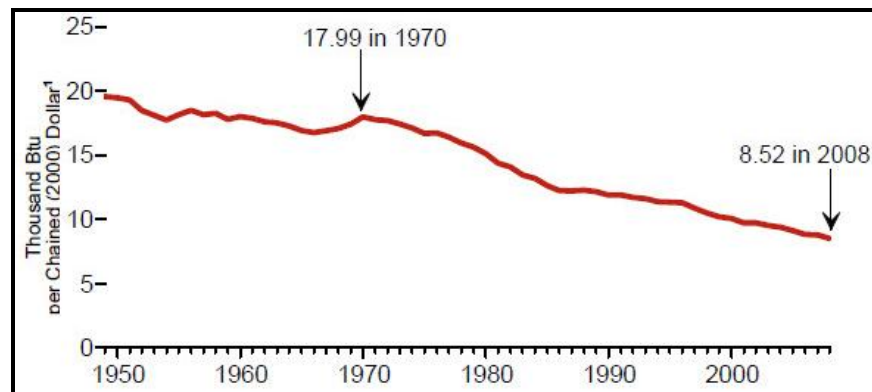


Figure 11 US Energy Consumption per real dollar of Gross Domestic Product⁵⁶

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Endnotes

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